

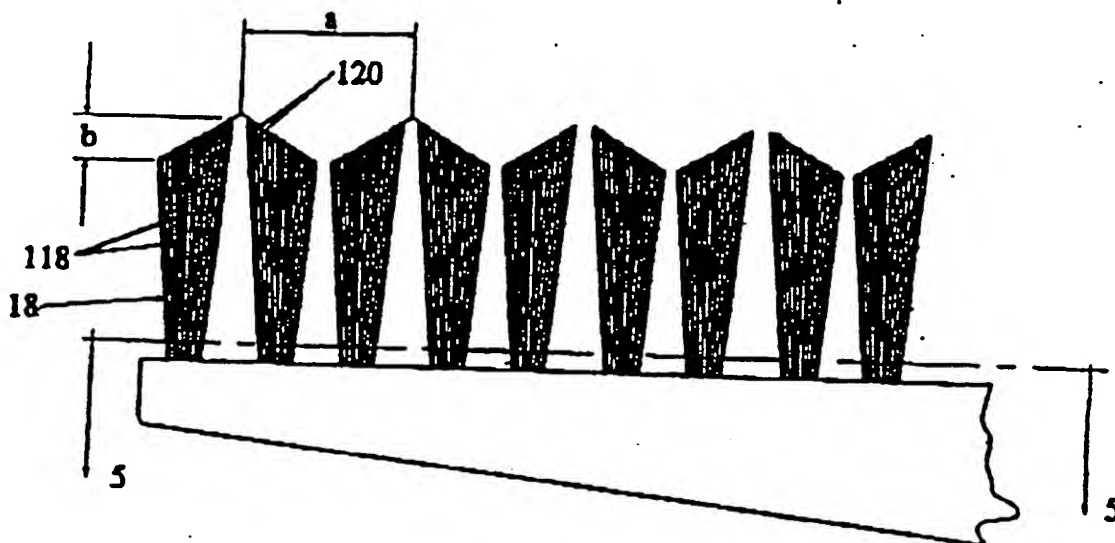
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(54) Title: TOOTHBRUSH EXHIBITING THREE-DIMENSIONAL BRISTLE PROFILE AND END ROUNDED BRISTLES FOR IMPROVED INTERPROXIMAL CLEANING WITHOUT INCREASING GUM IRRITATION



## (57) Abstract

A toothbrush is provided for achieving improved interproximal cleaning without increasing gum irritation. The bristles (118) of the toothbrush have a generally "V" shaped side profile. In addition, the exposed ends (120) of all of the bristles (118) are properly end rounded. The dimensions and shape of the "V" shape fall within a certain range, as does the stiffness of the bristles (118). These characteristics allow the bristles (118) to penetrate into the interproximal areas with enough force to effectively clean these areas without causing irritation to the user's gums.

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TOOTHBRUSH EXHIBITING THREE-DIMENSIONAL BRISTLE PROFILE  
AND END ROUNDED BRISTLES FOR IMPROVED INTERPROXIMAL CLEANING  
WITHOUT INCREASING GUM IRRITATION

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to toothbrushes, and more particularly, to toothbrushes which exhibit a three-dimensional bristle profile to provide improved cleaning in interproximal areas without increasing gum irritation.

2. Description of the Prior Art

The fundamental purpose of toothbrushes is to remove plaque and debris from tooth surfaces, both along their outer surfaces and in the interproximal areas. Most commercially available toothbrushes clean the outer surfaces of teeth adequately. However, applicants have discovered that a substantial improvement in toothbrush performance may be realized by optimizing toothbrush design for interproximal cleaning without sacrificing cleaning on the facial, lingual, buccal, and occlusal surfaces and without increasing gum irritation which often accompanies any attempt to improve interproximal cleaning. In particular, the present invention comprises an improved toothbrush having a "V" shaped pattern when viewed in side profile in combination with several other important operating characteristics which, when concurrently met, will render the toothbrush particularly adept at accomplishing the aforementioned objectives.

Toothbrushes having a "V" shaped side profile are generally known to those skilled in the art. However, it is believed that these known prior art toothbrushes do not exhibit all of the operating characteristics identified hereinafter as important to achieving improved interproximal cleaning without increasing gum irritation. For example, most of these prior "V" shaped toothbrushes lack bristles which are properly end rounded. This is due to the fact that the three-dimensional bristle pattern on such known brushes is often formed by cutting the exposed ends of the bristles to the desired configuration after the tufts have been

stapled to the brush head. This leaves bristle tips having sharp chisel pointed edges which are difficult to end round due to their three-dimensional configuration, particularly in the valleys. Although such brushes will provide improved interproximal cleaning, without properly end rounded bristles these toothbrushes will irritate the user's gums, oftentimes leading the user to abandon use of the brush. Clearly, the improved interproximal cleaning benefit will not be realized if people refuse to use the toothbrush. Consequently, it is important that the exposed ends of the bristles be properly end rounded to avoid unnecessarily irritating the user's gums.

In addition to proper end rounding of the exposed bristle tips, other important operating characteristics have been identified in "V" shaped toothbrushes of the present invention to achieve improved interproximal cleaning. In particular, the shape and size of the "V" and the overall stiffness of the bristles are important characteristics which must be optimized in accordance with the disclosure set forth in the present specification to provide all of the benefits of the present invention.

#### SUMMARY OF THE INVENTION

In accordance with one aspect of the present invention a toothbrush is provided which exhibits superior interproximal cleaning. The toothbrush includes an elongate member having a head portion. A multiplicity of bristles extend from the head portion of the elongate member and these bristles have their distal ends properly rounded to avoid irritation of the user's gums in use. The distal ends of the bristles form a substantially aligned generally "V" shaped pattern when viewed in side profile, with a peak-to-peak distance ranging from about 0.16 inches to about 0.30 inches and a peak height ranging from about 0.06 inches to about 0.18 inches. The bristles also exhibit a stiffness factor, as hereinafter defined, in the range of from about 0.2 to about 0.8.

#### BRIEF DESCRIPTION OF THE DRAWINGS

While the specification concludes with claims which particularly point out and distinctly claim the invention, it is believed the present invention will be better understood from the following description of several particularly preferred embodiments

taken in conjunction with the accompanying drawings, in which like reference numerals identify similar elements and wherein;

Figure 1 is a perspective view of a preferred embodiment of a toothbrush of the present invention;

5 Figure 2 is a side profile view of the toothbrush of Figure 1 illustrating the straight "V" side profile;

Figure 3 is a side profile view similar to Figure 2 of a second preferred embodiment of a toothbrush of the present invention having a sine wave "V" side profile;

10 Figure 4 is a side profile view similar to Figure 2 of a third preferred embodiment of a toothbrush of the present invention having a scallop "V" side profile;

Figure 5 is a cross-sectional plan view taken along line 5-5 of Figure 2 showing the bristle tuft pattern;

15 Figure 6 is a cross sectional plan view similar to Figure 5 illustrating an alternative bristle tuft pattern; and

Figure 7 is an end view of the toothbrush showing its position on a tooth during brushing.

#### DESCRIPTION OF PARTICULARLY PREFERRED EMBODIMENTS

20 In a particularly preferred embodiment seen in Figure 1, the present invention comprises a toothbrush, indicated generally as 10, for achieving improved interproximal cleaning without increasing gum irritation. Basically, the toothbrush 10 includes an elongate member 12 having a handle portion 14 and a head portion 16. For  
25 applications such as electric toothbrushes, the handle portion 14 may comprise suitable attachment means (not shown) for securing the brush head portion 16 to the driving means. The head portion 16 may comprise a generally rectangular area from which a multiplicity of bristle bundles or tufts 18 extend. The bristles 118 in tufts 18  
30 are properly end rounded to protect gum tissue. A particularly preferred method for providing three-dimensionally profiled tufts 18 wherein the individual bristles 118 exhibit high quality end rounding will be discussed in detail in the latter portions of the present specification.

35 Referring to Figure 2, the bristles 118 in tufts 18 are preferably arranged in a geometry which enables them to penetrate, or reach, into the interproximal areas between the user's teeth.

Without sufficient penetration between the teeth, much of the interproximal area will remain untouched by the bristles of the brush. To increase interproximal penetration, the distal ends 120 of the bristles 118 form a substantially aligned "V" shaped side profile. The preferred toothbrush embodiment 10 of Figure 1 has a substantially aligned straight-"V" shaped side profile, as best seen in Figure 2. Possible modifications to the straight "V" shaped side profile include a sine wave-"V" as best seen in Figure 3, or a scallop-"V" as best seen in Figure 4.

Referring to Figure 2 in conjunction with Figure 5, the bristles 118 of toothbrush embodiment 10 form a straight-"V" shaped side profile having five and one-half peaks. For an adult sized toothbrush, the total number of peaks preferably ranges from about three to about seven. The bristles 118 which extend from the head portion 16 of the elongate member 12 are grouped together into a plurality of bundles or tufts 18. Each tuft 18 preferably includes bristles 118 of various lengths which helps increase the ability of each tuft 18 to reach into the interproximal areas. As can be seen in Figure 2, although the individual bristles 118 within the tufts 18 exhibit good end rounding, the overall profile of each tuft 18 of the first ten rows is that of a single edged chisel. Since there is an odd number of rows the tufts 18 of the last row adjacent the handle portion 14 of the brush exhibit a double chisel or wedge shaped profile when viewed in side elevation to reduce stress on the last row, thereby increasing durability. Although Figure 2 discloses the preferred configuration where two transverse rows of tufts form a peak, anywhere from one to three rows of tufts 18 may be used to form a peak and the number of tufts 18 per peak need not be consistent throughout the brush head 16. Likewise, as can be seen in Figure 5 the number of tufts 18 per row need not be consistent throughout the brush head 16.

The distance from one peak to another peak (peak spacing) directly impacts the ability of the tuft 18 to penetrate into the interproximal zone. This peak spacing distance is indicated as "a" in Figures 2-4, and is the distance between the theoretical peaks if there is no actual peak. An acceptable peak spacing "a" is preferably defined according to average human teeth geometries, as

represented by the Columbia DENTOFORM model R861, as available from The Columbia Dentoform Corporation of Long Island City, New York. The peak spacing range employed in the practice of the present invention is preferably about one third less than the average geometry range to allow for maximum bristle buckling and bending during the back-and-forth stroke of the brush. Consequently, for an average human tooth width of about 0.33", a minimum human tooth width of about 0.23" and a maximum human tooth width of about 0.46", as taken from the DENTOFORM model R861, the preferred peak spacing "a" for brushes of the present invention preferably ranges from about 0.16" to about 0.30", and even more preferably, from about 0.19" to about 0.25".

In addition to peak spacing, the depth of the "V" (peak height) also impacts interproximal penetration. This distance is indicated as "b" in Figures 2-4. It is the distance from the bottom to the top of the "V" on the tuft 18. Like peak spacing, the interproximal depth may be defined according to average teeth geometries based on the Columbia DENTOFORM model R861 described earlier herein. From the DENTOFORM model R861, the average interdental depth is about 0.14" with a range of from about 0.10" to about 0.17". Accordingly, the preferred peak height "b" in brushes of the present invention preferably ranges from about 0.06" to about 0.18", and even more preferably, from about 0.09" to about 0.16".

In addition to having peak spacing "a" and peak height "b" values within the appropriate ranges, peak spacing "a" is preferably about twice peak height "b".

This "V" shaped profile must be substantially aligned across the brush head in the transverse direction. Mis-alignment of the V shaped profile causes bristles to interfere with, i.e., contact, the outer surfaces of the user's teeth. If too many bristles interfere with adjacent teeth they reduce the ability of the bristles aligned with the interproximal areas to penetrate into the interproximal areas. Furthermore, better cleaning results when the tufts 18 of each row are preferably aligned with one another in the transverse direction, i.e., parallel to the width of the brush head 16 as seen best in Figure 5. In other words, row alignment across the width occurs when the tufts 18 form a straight line, perpendicular to the

lengthwise axis of the elongate member 12 (seen in Figure 1). Therefore, the tufts 18 of each row are preferably aligned in the transverse direction.

Overall penetration is also affected by the longitudinal row spacing between adjacent tufts 18. Longitudinal row spacing is the longitudinal distance between adjacent tufts 18, as measured in a direction parallel to the length of elongate member 12, and is indicated as "c" in Figure 5. Since longitudinal row spacing "c" may not be completely uniform throughout the head portion 16 of the toothbrush an average value is calculated. Increasing the longitudinal row spacing "c" allows more free movement of individual tufts 18 which tends to improve penetration. The longitudinal row spacing "c" preferably ranges from about 0.02 inches to about 0.08 inches, and even more preferably from about 0.04 inches to about 0.07 inches.

In addition to being able to penetrate into the interproximal areas, the bristles 118 on toothbrushes of the present invention must be sufficiently stiff to generate enough force to remove plaque and debris in these interproximal areas.

The bristles 118 in combination have a bristle stiffness which can be characterized numerically by the following equation:

$$\text{Bristle Stiffness} = \frac{D^2 E}{X^2} \times \frac{(\# \text{ Bristles})}{1 \times 10^6}$$

where; D = bristle diameter, in inches  
E = modulus of elasticity of the bristle material when wet, e.g. for nylon this is a constant, 460,000 psi  
X = average bristle length across the head 16 of the brush in inches  
# bristles = total number of bristles on brush head 16

The bristle stiffness for brushes of the present invention, as determined by the above equation, preferably ranges from about 0.2 to about 0.8.

The initial stiffness calculation,  $\frac{D^2 E}{X^2}$  for an individual bristle 118 is a measure of the pressure produced by the minimum force required to deflect a single bristle 118 according to The Stiffness of Toothbrushes, D.W. MacFarlane, Brit. Dent. Jour.,



10/5/45, which is hereby incorporated herein by reference. Bristle stiffness is obtained by multiplying this single bristle stiffness value by the total number of bristles 118 on the brush head 16. The factor  $1 \times 10^6$  used in the denominator of the foregoing equation is  
5 an arbitrarily selected constant which reduces the overall bristle stiffness value to reasonably small numbers for ease of comparison.

The diameter "D" of bristles 118 employed in toothbrushes of the present invention preferably ranges from about 0.006 inches to about 0.009 inches. Average bristle length "X" preferably ranges  
10 from about 0.30 inches to about 0.55 inches and even more preferably from about 0.34 inches to about 0.44 inches. The total number of bristles 118 in the head portion 16 of brushes of the present invention is preferably from about 1,200 to about 5,000, and even more preferably from about 1,600 to about 3,500.

15 In addition to the foregoing bristle stiffness characteristic, buttressing also affects stiffness. Buttressing is the tendency of adjacent bristles to support or buttress each other. Within a tuft, more tightly packed bristles 118 provide additional support adding to the effective stiffness of the bristles 118. Optimum Buttressing  
20 occurs when all bristles 118 are touching, i.e. no staple is used. In this case the number of bristles 118 in a hole are maximized and the tight packing maximizes the degree of support these bristles 118 give to each other. Since buttressing is a measure of the efficiency by which a tuft 18 of bristles 118 are packed together, a  
25 numerical value, termed Buttress Factor, is achieved by dividing the cross-sectional area taken up by the bristles 118 by the total cross sectional area of the tuft 18 at the base. Numerically, the preferred Buttress Factor for brushes of the present invention ranges from about 0.8 to about 0.96.

30 Buttressing from tuft to tuft also affects stiffness. Tuft to tuft interaction between columns is affected by the transverse column spacing, indicated as "d" in figure 5. Like longitudinal row spacing "c", transverse column spacing "d" may not be completely uniform throughout the head portion 16 of the toothbrush, therefore,  
35 an average value is used.

Reducing transverse column spacing "d" effectively increases the overall bristle stiffness of tufts 18. As seen in Figure 7,

with the typical back-and-forth stroke, i.e., in and out of the plane of the paper on which Figure 7 appears, and a generally 45 degree brush head angle in relation to the exposed surfaces of tooth 22, adjacent tufts in a row are spread out across the crowns of the tooth 22. As they are spread, closer transverse column spacing "d" effectively increases the overall bristle stiffness of the brush as the outer tufts 18 support the inner tufts 18, forcing them into interproximal spaces between adjacent teeth.

The toothbrush embodiment 610 of Figure 6 effectively eliminates the transverse column spacing "d" between adjacent tufts 618, since each tuft 618 extends substantially continuously across the width of the brush head. The tufts 618 of the illustrated embodiment are oblong, although they could also be oval or rectangular. Due to the beneficial effects of tuft to tuft buttressing between columns, transverse column spacing is preferably from zero to about 0.08 inches.

Tuft to tuft interaction between rows is affected by the longitudinal row spacing "c". The previously noted preferred ranges for longitudinal row spacing "c" reflects a balance between desired penetration for interproximal cleaning and desired buttressing for surface scrubbing.

A preferred method of achieving end rounded bristles 118 in a "Y" shaped format is to first square cut or shear a group of bristles 118 perpendicular to the length of the bristles 18. The cut ends of the bristles 118 are then ground while in a common plane to remove any sharp or protruding edges from each bristle 118. The bristles 118 are then moved relative to each other to produce a desired three-dimensional shape at the exposed end of the tuft 18. The attachment end of the bristles 118 are then preferably square cut or sheared to the appropriate length. This method is further described in German Patent Application 3820372 which published on December 20, 1989, which is hereby incorporated herein by reference. The attachment end of the bristles 118 is then preferably heated to form a molten mass and placed against the heated head portion 16 of the elongate member 12. As the molten materials cool, the tufts are secured to the head portion 16 of the elongate member 12. The latter method is further described in United States Patent 4,637,660

which issued on January 20, 1987 to Weihrach, which is also hereby incorporated herein by reference.

The dimensions and characteristics of one exemplary toothbrush embodiment similar to that illustrated in Figure 1 may include the following:

\* Fundamental Parameters

"V" profile - 5 1/2 peaks

Rows aligned

10 Square-cut, optimally end-rounded bristles which are three-dimensionally contoured after end rounding

\* Optimized Parameters

15 Stiffness - bristle diameters .007"  
- bristle length .35-.43" (avg.=.39)  
- total number of bristles 2052  
Stiffness = .30

Buttressing

- Buttress Factor 0.87  
- "d" .05"

20 Penetration - peak spacing

- peak height .22"  
- alignment .09"  
- "c" total .05"

Overall head size (0.71" to 1.3" X 0.32" to 0.50")

25 The dimensions and characteristics of a second preferred embodiment similar to that illustrated in Figure 6 may include the following:

\* Fundamental Parameters

"V" profile - 5 1/2 peaks

30 Rows aligned

Square-cut, optimally end-rounded bristles which are three-dimensionally contoured after end rounding

\* Optimized Parameters

35 Stiffness - bristle diameters .007"  
- bristle length .35-.43" (avg.=.39)  
- total number of bristles 3800  
Stiffness = .56

Buttressing

- Buttress Factor 0.87  
- "d" 0.0"

40 Penetration - peak spacing

- peak height .22"  
- alignment .1"  
- "c" total .05"

Overall head size (0.71" to 1.3" X 0.32" to 0.50")

Although particular embodiments of the present invention have been shown and described, modification may be made to the toothbrush without departing from the teachings of the present invention.

5 Accordingly, the present invention comprises all embodiments within the scope of the appended claims.

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## WHAT WE CLAIM IS:

1. A toothbrush exhibiting superior interproximal cleaning without increasing gum irritation comprising:
  - (a) an elongate member having a head portion;
  - (b) a multiplicity of bristles extending from the head portion of the elongate member and having their distal ends rounded, the distal ends of said bristles forming a substantially aligned generally "V" shaped side profile having a peak spacing "a" from about 0.16 inches to about 0.30 inches and a peak height "b" from about 0.06 inches to about 0.18 inches, the bristles further having a stiffness in the range from about 0.2 to about 0.8.
2. A toothbrush exhibiting superior interproximal cleaning without increasing gum irritation comprising:
  - (a) an elongate member having a head portion;
  - (b) a multiplicity of bristles extending from the head portion of the elongate member and having their distal ends rounded, the distal ends of said bristles forming a substantially aligned generally "V" shaped side profile having a peak to peak distance from about 0.19 inches to about 0.23 inches and a peak height from about 0.09 inches to about 0.16 inches, the bristles further having a stiffness factor in the range from about 0.2 to about 0.8.
3. A toothbrush according to Claim 1 wherein each bristle is in contact with all adjacent bristles at the point of attachment to the head portion of the elongate member.
4. A toothbrush according to Claim 2 wherein each bristle is in contact with all adjacent bristles at the point of attachment to the head portion of the elongate member.
5. A toothbrush according to Claim 1 wherein the bristles are attached to the head portion of the elongate member such that they have a Buttress Factor from about 0.8 to about 0.96.

6. A toothbrush according to Claim 2 wherein the bristles are attached to the head portion of the elongate member such that they have a Buttress Factor from about 0.8 to about 0.96.
7. A toothbrush according to Claim 1 wherein the peak spacing "a" is twice the peak height "b".
8. A toothbrush according to Claim 2 wherein the head portion has a longitudinal length from about 0.71 inches to about 1.30 inches and a transverse dimension from about 0.32 inches to about 0.50 inches.
9. A toothbrush according to Claim 1 wherein the longitudinal row spacing between bristle tufts is from about 0.02 inches to about 0.08 inches.
10. A toothbrush according to Claim 2 wherein the longitudinal row spacing between bristle tufts is from about 0.02 inches to about 0.08 inches.
11. A toothbrush according to Claim 1 wherein the transverse column spacing between bristle tufts is from about zero to about 0.08 inches.
12. A toothbrush according to Claim 2 wherein the transverse column spacing between bristle tufts is from about zero to about 0.08 inches.
13. A toothbrush according to Claim 1 wherein the total number of bristles extending from the brush head is from about 1,200 to about 5,000.
14. A toothbrush according to Claim 2 wherein the total number of bristles extending from the brush head is from about 1,200 to about 5,000.
15. A toothbrush according to Claim 1 wherein the average bristle length is from about 0.35" to about 0.43".

16. A toothbrush according to Claim 2 wherein the average bristle length is from about 0.35" to about 0.43".

17. A toothbrush according to Claim 1 wherein the "V" shaped pattern includes three to seven peaks.

18. A toothbrush according to Claim 2 wherein the "V" shaped pattern includes three to seven peaks.

19. A toothbrush according to Claim 1 wherein the head portion has a longitudinal length from about 0.71 inches to about 1.30 inches and a transverse dimension from about 0.32 inches to about 0.50 inches.

20. A toothbrush according to Claim 2 wherein the head portion has a longitudinal length from about 0.71 inches to about 1.30 inches and a transverse dimension from about 0.32 inches to about 0.50 inches.

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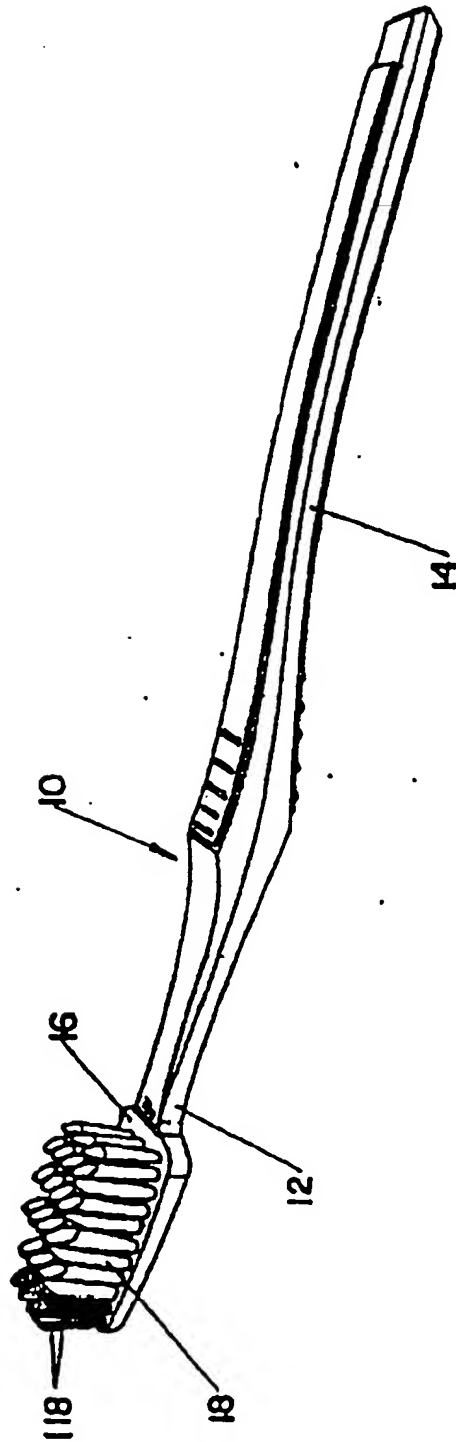
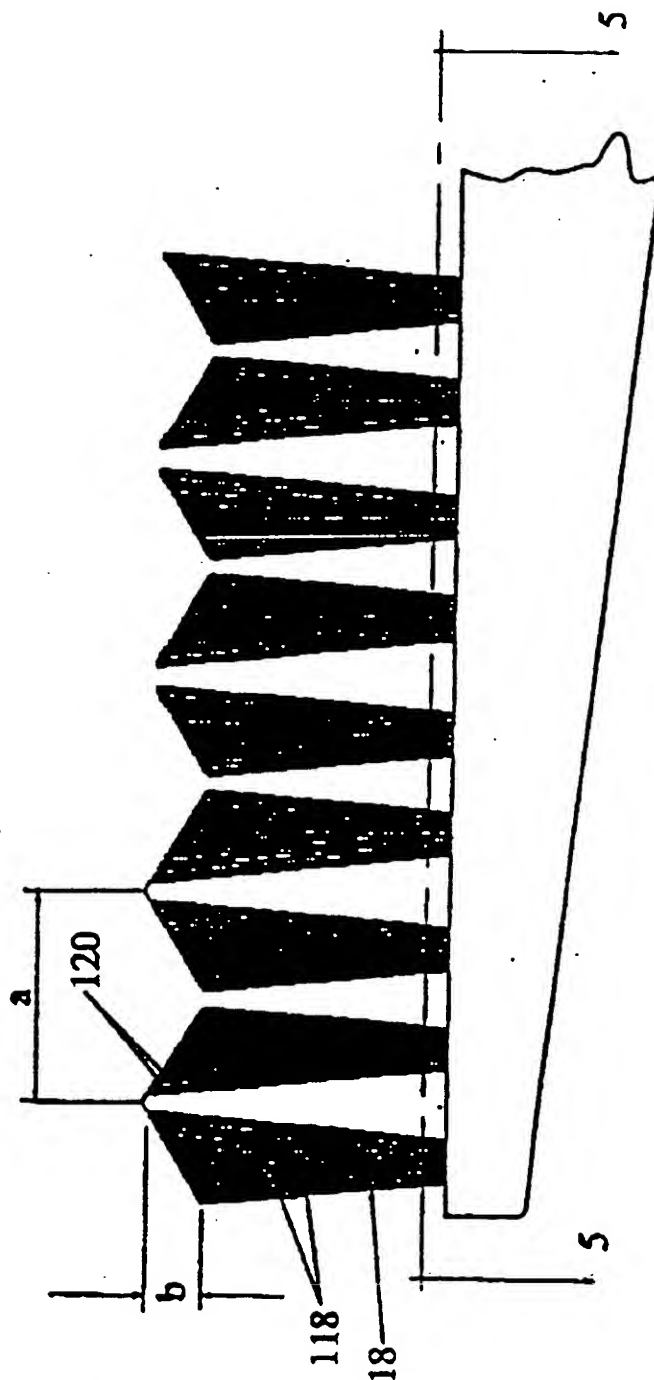


FIG. 1

SUBSTITUTE SHEET





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Fig. 2

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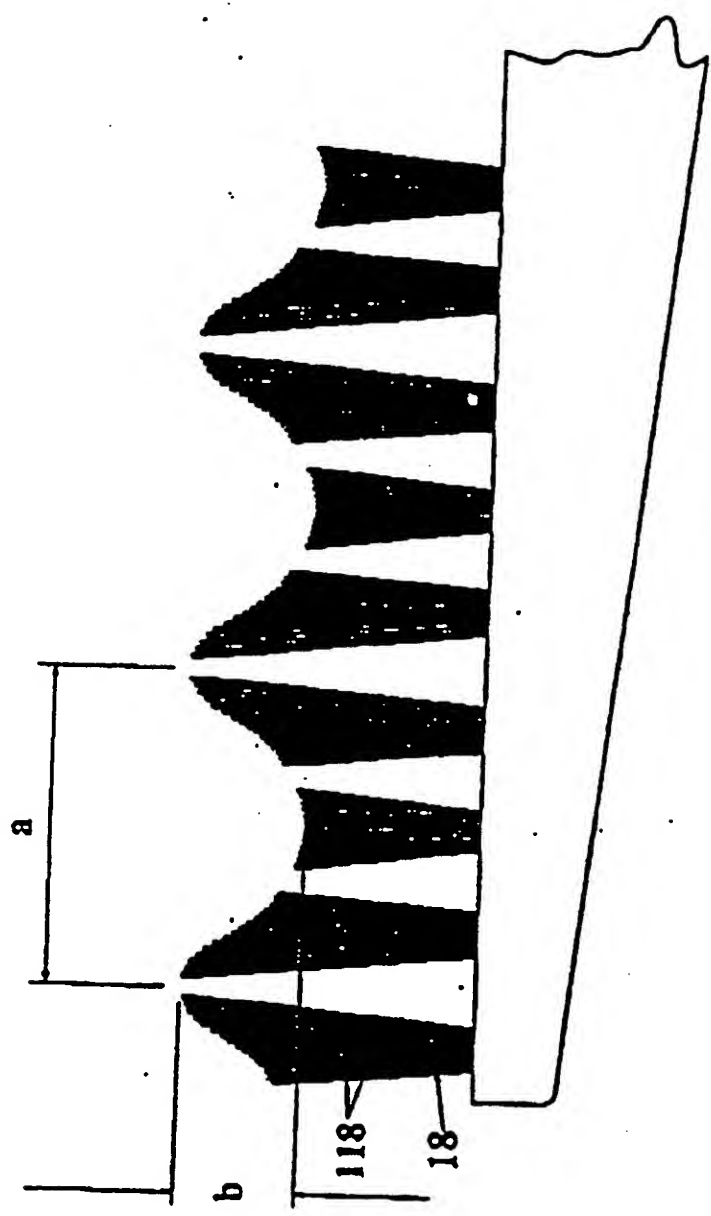


Fig. 3

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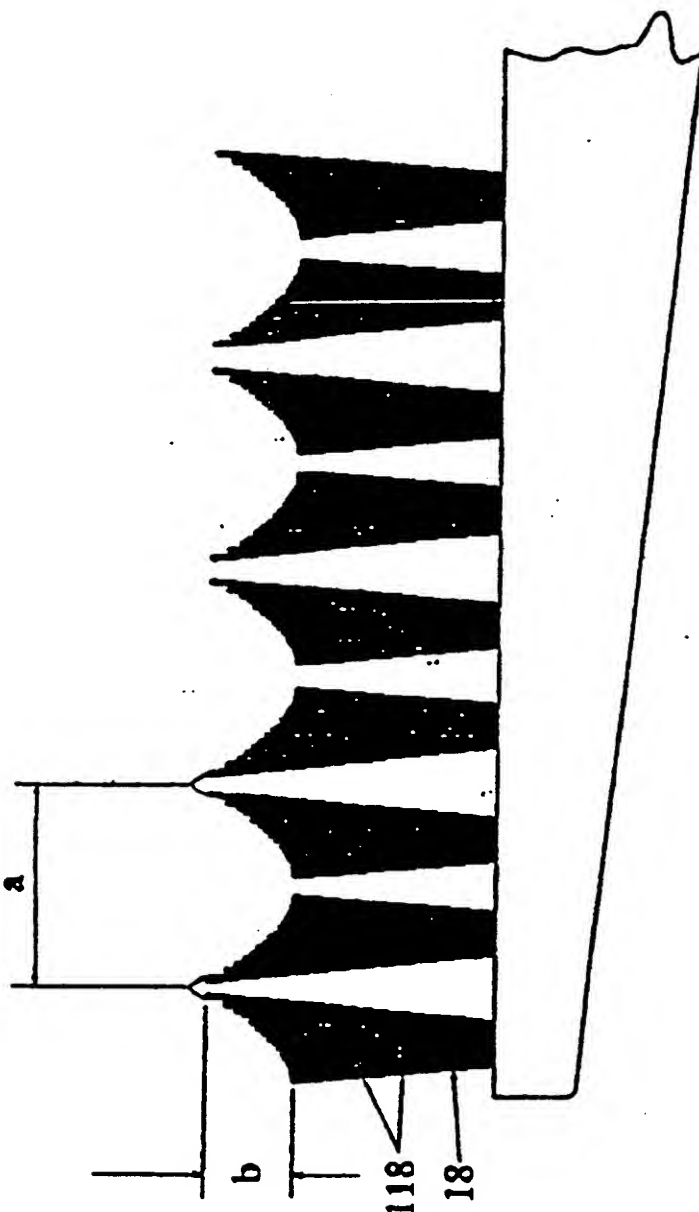


Fig. 4

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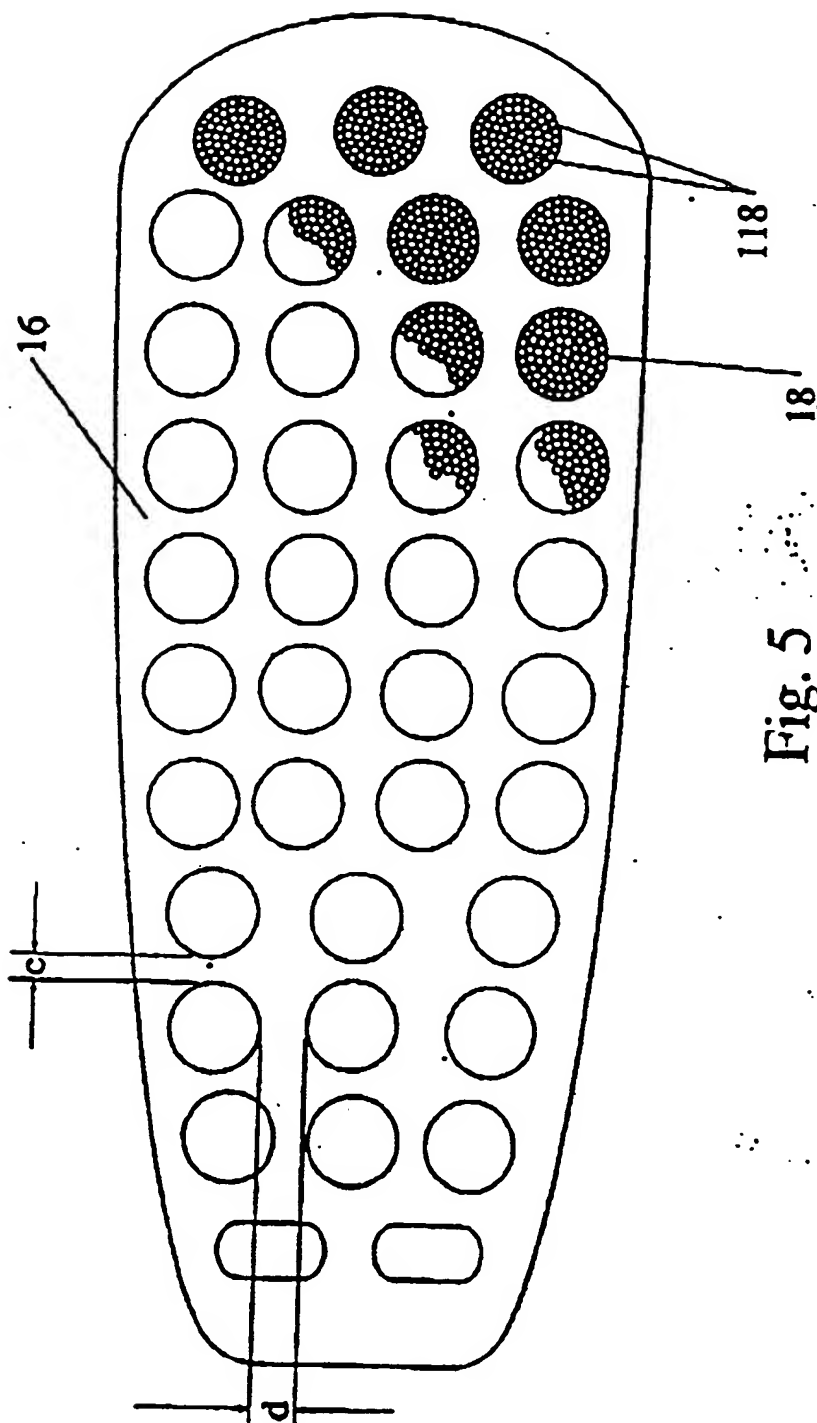


Fig. 5

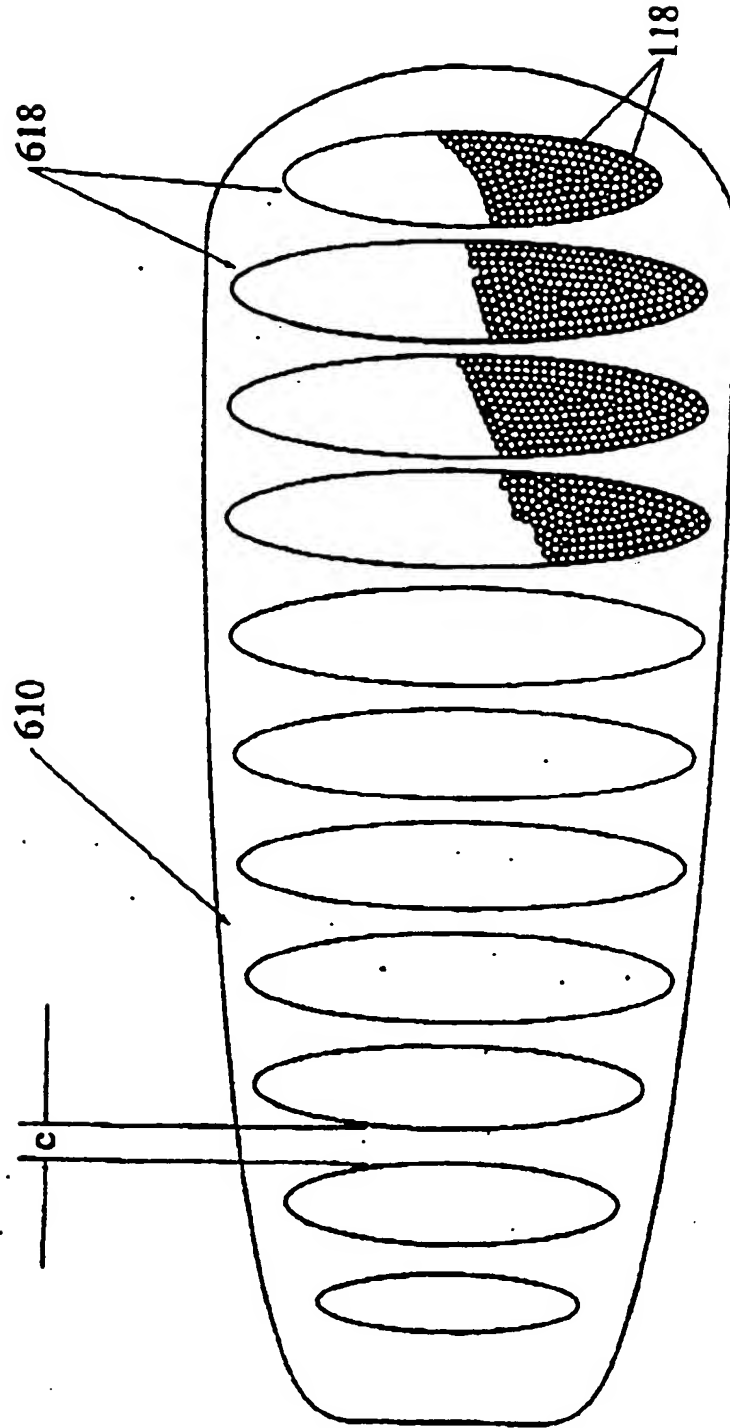


Fig. 6

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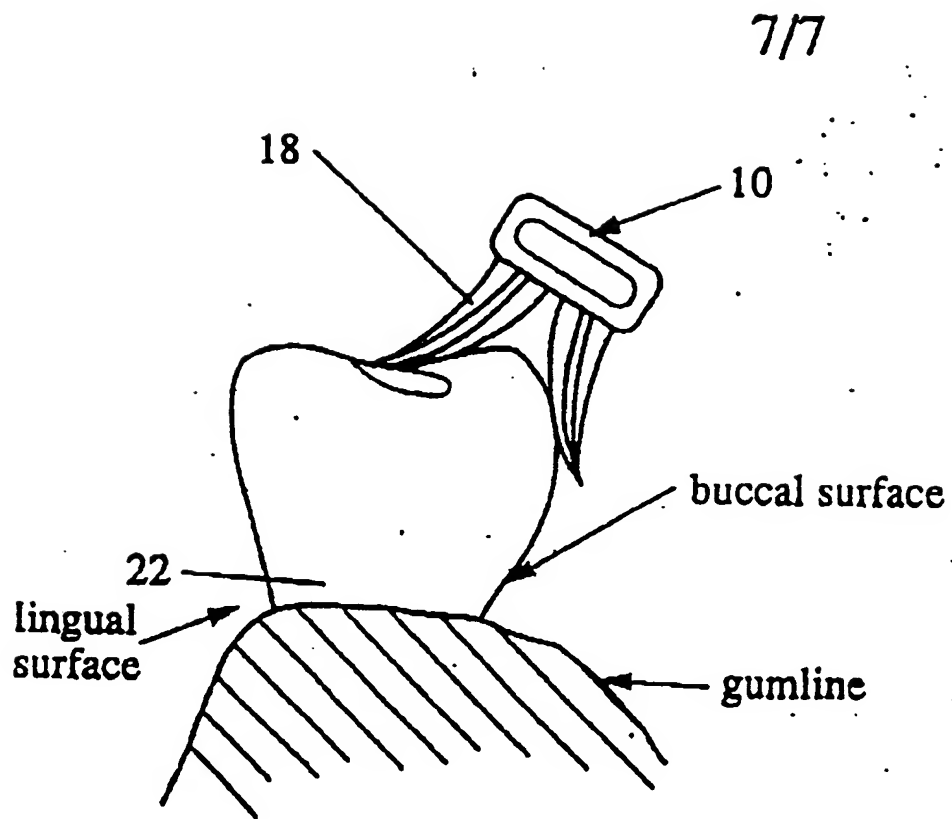



Fig. 7

## INTERNATIONAL SEARCH REPORT

International Application No.

PCT/US 91/03769

<b>I. CLASSIFICATION OF SUBJECT MATTER</b> (If several classification symbols apply, indicate all)*		
According to International Patent Classification (IPC) or to both National Classification and IPC:		
Int.Cl. 5      A46B9/04		
<b>II. FIELDS SEARCHED</b>		
Minimum Documentation Searched <sup>2</sup>		
Classification System	Classification Symbols	
Int.Cl. 5	A46B ;      A46D	
Documentation Searched other than Minimum Documentation to the extent that such Documents are included in the Fields Searched <sup>2</sup>		
<b>III. DOCUMENTS CONSIDERED TO BE RELEVANT<sup>3</sup></b>		
Category <sup>4</sup>	Citation of Document, <sup>11</sup> with indication, where appropriate, of the relevant passages <sup>12</sup>	Relevant to Claim No. <sup>13</sup>
Y	US,A,3188673 (NEWMAN) 15 June 1965 see column 1, line 55 - column 3, line 12; figures 1-4 ---	1-20
Y	EP,A,0346646 (CORONET-WERKE) 20 December 1989 see claim 1 & DE,A,3820372 (cited in the application) ---	1-20
<p>* Special categories of cited documents: <sup>10</sup></p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"B" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubt on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published after the international filing date or priority date and not in conflict with the invention but cited to substantiate the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"A" document member of the same patent family</p>		
<b>IV. CERTIFICATION</b>		
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	
01 AUGUST 1991	27. 08. 91	
International Searching Authority	Signature of Authorized Officer	
EUROPEAN PATENT OFFICE	ERNST R.T. 	

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ANNEX TO THE INTERNATIONAL SEARCH REPORT  
ON INTERNATIONAL PATENT APPLICATION NO.

US 9103769

SA 48390

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

02/08/91

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A-3188673		None	
EP-A-0346646	20-12-89	DE-A- 3820372	21-12-89
		AU-A- 3646889	21-12-89
		JP-A- 2111305	24-04-90
		US-A- 4979782	25-12-90

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